Recent Improvements to NuMI, Minerva Release & relevance to NuMI-X

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# Outine

- ✔ Minerva Release

    – Improvements to the existing geometry.

    • Water layer

    • Accurate Horn1 Inner Conductor.

    – Tools for debugging

    – Constraints from X-section re-weighting capabilities.

- ✔ Path to the NuMI-X release.. Thoughts/discussion.

Water Layer on Inner Conductor

It is there.. In the range of 0.5 to 1.5 mm (Cory F. Crowley, private comm. To Laura F, Mike Kordosky, my self) . Assumes phi-symmetric in G4NuMi, but, in reality, probably twice thicker in bottom than top.

- ✔ Installed now in the G4NuMI, version used by LBNE and Minerva. (Also installed, kind o inadvertently, on the "optimized BNB Horn1", as I am "re-using" G4 code.)
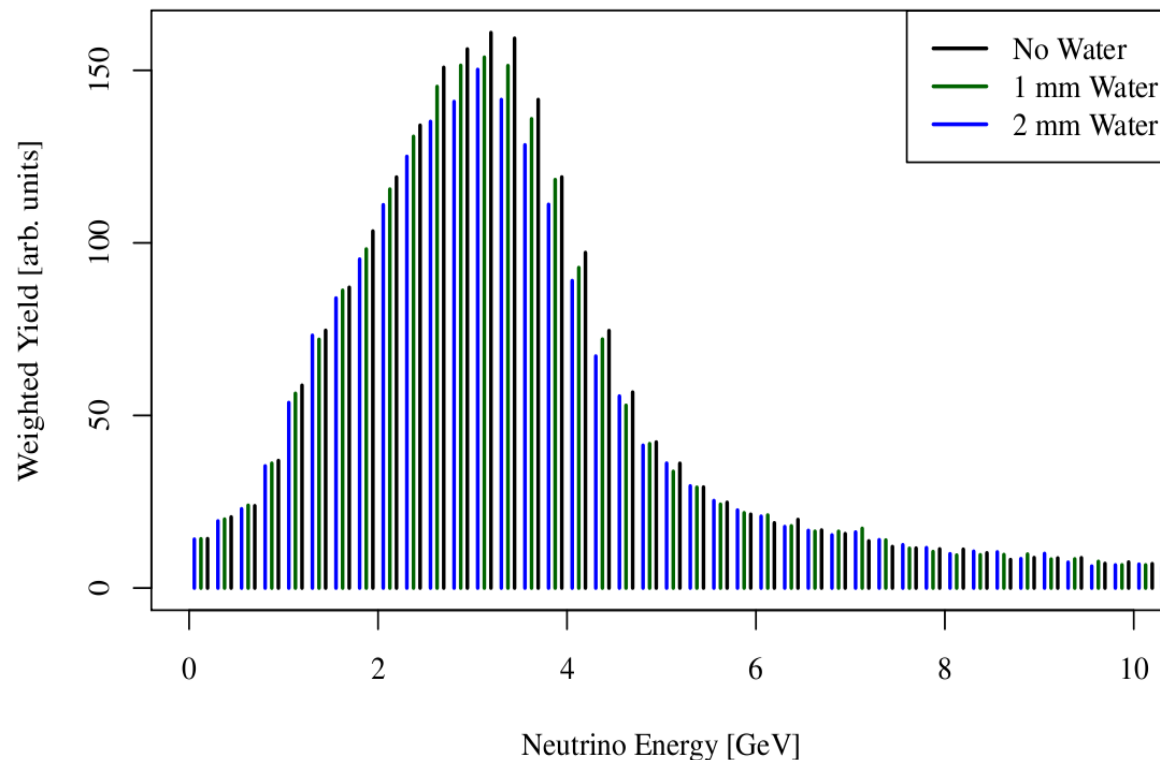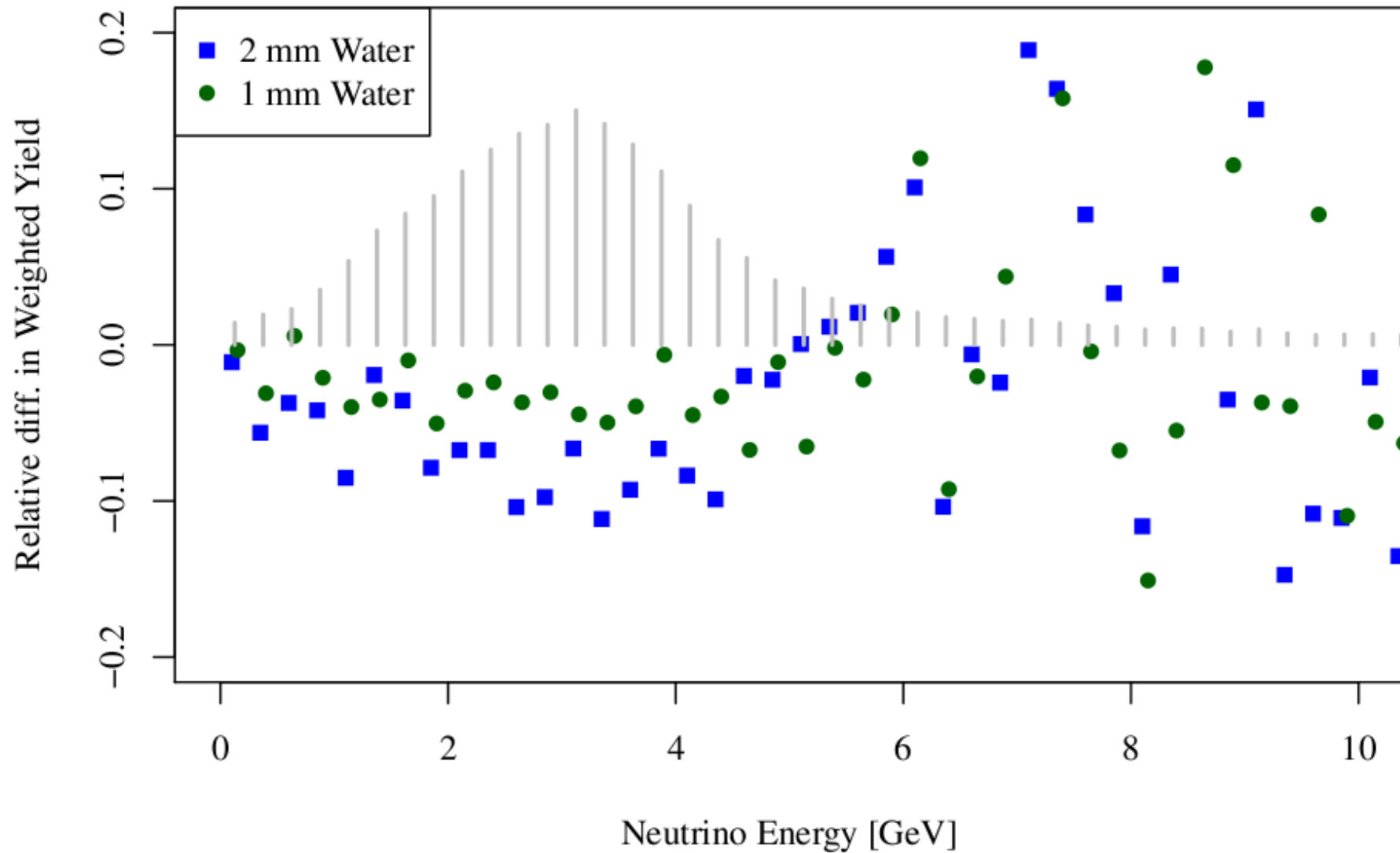
... My own quick study dating.. October 2014...   (Minerva Docdb 10406)
Better statistics obtained by my Minerva colleagues.

Horn1 Inner Conductor Modeling...

- Characterized by a parabolic shape.. discontinuous (Neck is usually straight..)

- ==> Need to be modeled as a set of "G4Cons" (Cones), a (few?) polygons. How to choose the segmentation ?

- It looks like a nutty-gritty details of Geant4 programming...

- Yet, why not trying different implementation, all presumably based on the same of blue prints (that are now 15 years old..), could give different yields..

- Using ad hoc visualization techniques on geantinos (non-interacting straights) can help us differentiate among version:
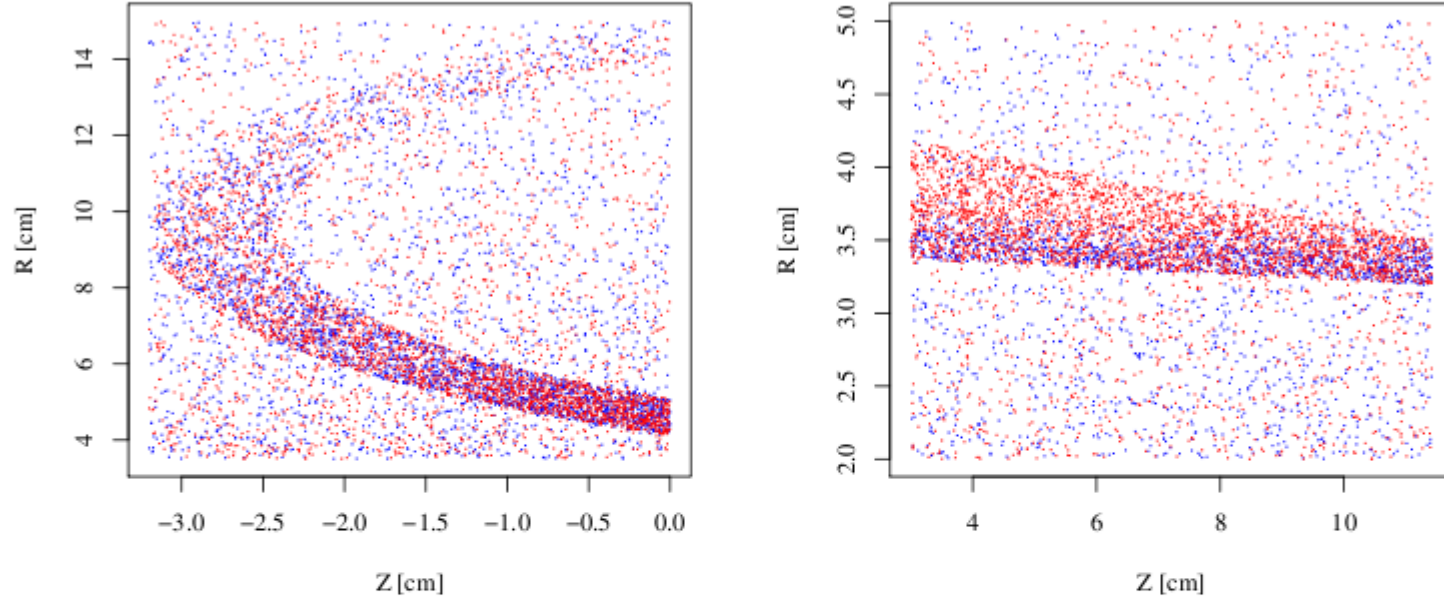
Figure 3: A scatter plot of the generated vertex positions of pions that do generate a neutrino in the decay pipe, on the R/Z plane, for a limited range in Z coordinate. Blue points corresponds to the Nominal geometry, red to the Alternate geometry, respectively. The coordinates are expressed in the G4 "world coordinate" system, with $Z = 0$. pinned at the MCZero line, stated on the drawing shown on figure 1. Therefore, on the left plot, we have the most upstream section of the horn conductor, inner to outer transition (I/O). On the right hand side plot, we have the connecting piece just after the I/O torus. Only the first 4,000 points in the sample are plotted, for graphical clarity.
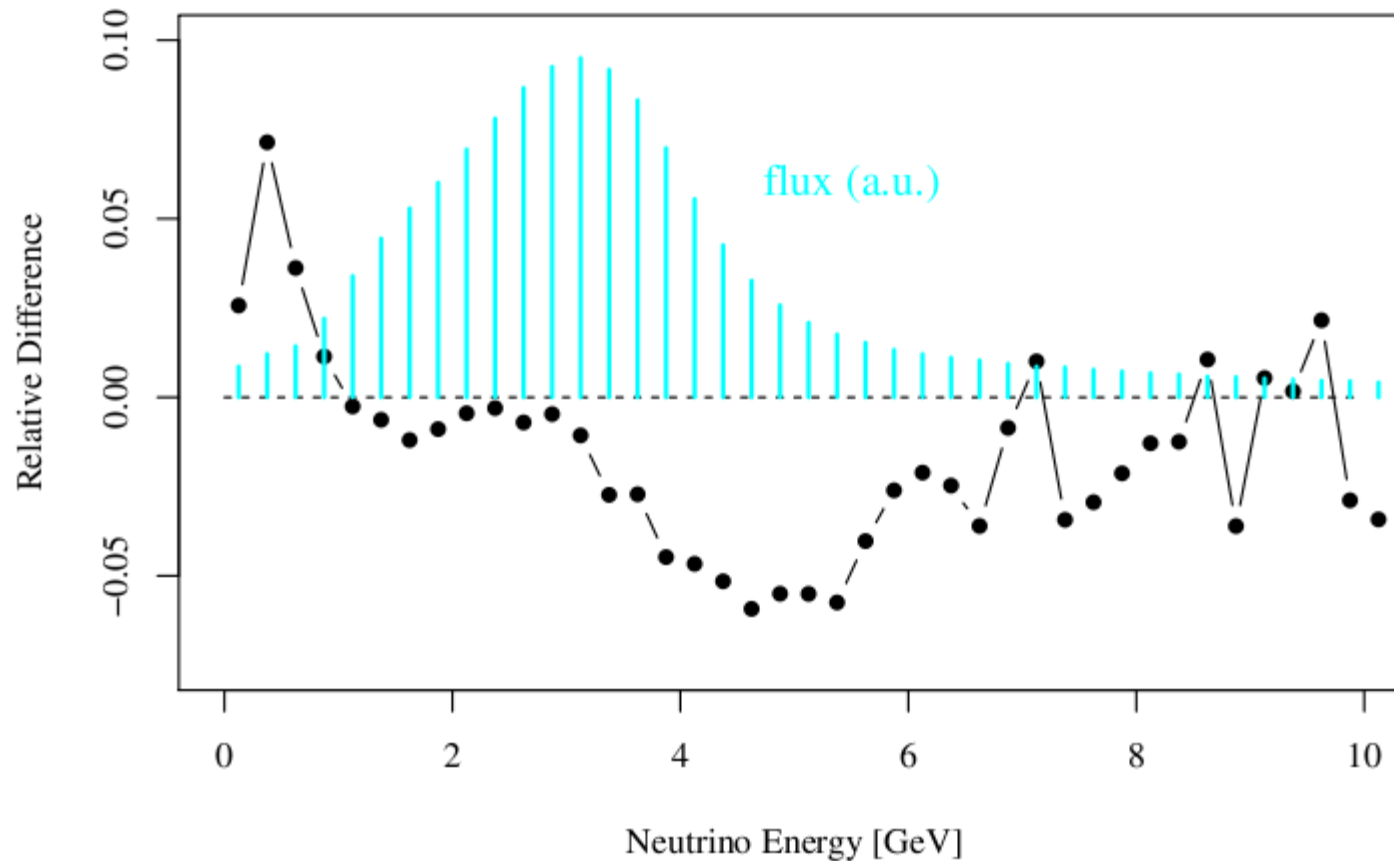
Running an Alternate geometry for Horn1.   (constructed for LBNE, more than 2 years ago.)
Re -installed in G4Numi, Minerva release
Compared to default NuMi, elements by elements..
Debug with "radiography with Geantino" (Path length calculations for well controlled straights..)

(Minerva Docdb 10573)

Inner Conductor Modeling.. Precision

Most critical region is around the neck of horn1, where, in Numi, the neck is not an exact cylinder, but a smooth, parametric, but segmented shape.

Learned Lessons :

Tedious! Very much time consuming... Reliable tools not quite there..

Note: a fully automated CAD ->Geant4 has not been used, simply because the level of details required for machining and physical assembly are quite distinct from modeling

So "physics judgement" has to be introduced, blue-prints after blue-prints (Spider hangers details, Strip line connections...)

And.. _It better be reviewed by independent minds..._

But.. Not everybody has easy access to blue prints.. (ADMS-I-Find not accessible for FNAL outsiders).

Thoughts are how to proceed...

✔ More a discussion, not a lecture!

✔ Advantage of maintaining releases of G4NuMI (if not already discussed by Rob..)

  – Non standard versions of Geant4..

  • LBNE ==> Checking overlaps for G4Cons buggy for later releases of V4.9.4. Perhaps fixed in v4.10.1

  • Minerva: Need to access which nuclei was hit by an "Inelastic proton" such that A-dependence and re-weighting studies can take place.

  • Fluka/MARS interfaces may differ.

  – Goals in trading tracing accuracy vs CPU speed might differ...

  – Tools preferences: Advanced 3D visualization vs simple trajectory studies ==> different I/O sub-systems.

  – Life-cycles don't always match.. Nova vs "good-old Minos, and don't touch it.."

  – Man-power availability for "certification"

✔

Portability of Improvements.

- Geant4 is OO, C-plush-plush, i.e. " a big spaghetti plate, but everything is labeled and traceable." So, to some extend, modular.

- This means that, should we have to support multiple branches (or releases, or tagged release, on either CMS or Git), it is not the end of the world if we have to re-implement a given feature in a given release, if it has been implemented once.. Note:

    – Only a fraction of the time to implement a given improvement is spend on coding. Debugging and certification is the tricky part. Not to be re-done 100% in each release (a case by case issue)

- Assuming we all use a fairly stable available version of GNU C++, and compiler (C++11, C++14, etc..)

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A possible strategy.

- ✔ On a case by case basis, NuMIX collaborators are given access to a specific G4-User module, method, bits and pieces of code. Which...

  - – Hopefully, is not relying (too much) on new(est!) version of geant4 or C++ compiler, such that NuMI-X runs on Fermilab Scientific Linux 6 (7?)..

  - – However, NuMI-X will not "stay -behind"..

- ✔ The improvement is then implemented in the NuMIX-release

- ✔ Case by case...

- ✔ NuMIX is "open code" (of course).

- ✔ More issues to come !...

Opinions....

- While we may – or may not! - save man-power in the short term, having a version of NuMI beam line which has all known improvements and is well maintained is definitely worth having...

- In the upcoming era of "irreproducible" (too much $$ to redo a specific experiment..) results, this has value..

- Cost estimates must be made.. based on empirical data..